PATENT SPECIFICATION

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COMPLETE SPECIFICATION

ERRATUM

SPECIFICATION NO. 764,594

Page 1, line 9, *for* "a periodicity" *read* "aperiodicity".

THE PATENT OFFICE,
1st April, 1957

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vehicle, allowing of a certain degree of absorption of shocks in the case of their undergoing an upward or downward thrust as the sprung wheels are rolling along. The suspension is intended to make the pressure on the road-bed steady but the vertical tensile stress and the pressure on the suspension cause a rocking of the chassis, the period of the oscillations being on the one hand in relation to the mass of the chassis and the other hand to the pliability of the support. As the vertical rocking caused by the unevenness of the road of the track is repeated for a longer or shorter length of time after a shock has been undergone by the wheel, there may again occur, should there be a repetition of shock, a resonance between these vibrations and the swaying of the chassis and this increases the vertical swaying and the discomfort experienced by the load conveyed.

In order to remedy these inconveniences as far as possible, the wheel supporting axle is usually connected with the chassis by means of a shock-absorber the use of which is to operate against the movement of the spring. Whether its braking action is gradual or is applied one way only, however, it will be detrimental to the sensitiveness of the elastic support, even though it may previously have been devised as adjustable, or to a certain degree automatic according to the speed of the vehicle, the load conveyed, or the general condition of the road or railway-line, for the need of preserving the sensitiveness of the suspension retards the absorption of the rocking of the chassis resulting from shocks, this taking place even automatically as the result of adjust-

pression and extension of the elastic support.

According to the present invention there is provided a suspension system for fitment between two relatively movable parts (such as the wheel of a vehicle and the transported load or chassis) which comprises two elastic members arranged or mounted so that the movement of the two relatively movable parts is equal to the sum of the two motions performed by the elastic members, said motions assuming different proportions in relation with each other, each one of said elastic members being controlled by an associated shock-absorber, said shock-absorbers having a one-way braking action, the effective braking of one shock-absorber being carried out in reverse direction to the other, one of said shock-absorbers being effective when the imposed load moves towards the other movable part, the second shock-absorber coming into action while said part is moving in opposite direction.

The suspension of this invention may be constructed in many different ways, the elastic support always including two springs, one working under compressive strain and the other under tensile stress in relation to an average position of equilibrium, each one of said members being appropriately controlled through the braking action of a shock-absorber.

In order to form a clear understanding of the characteristics of the invention and what its objects are, two different variants of its applications are herewith described and illustrated diagrammatically by way of example.

Thus are given the following diagrams in vertical section:—

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COMPLETE SPECIFICATION

Improvements relating to Suspension Systems

I, ANDRE GRIMAUD a French citizen, of 33, Rue de la Couate, Foix, Ariège, France, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The object of the present invention is to provide a periodicity in suspension systems for vehicles.

Leaf or coil springs, hard rubber, torsion rods, i.e., resilient supports are known to be used between the wheels and chassis of the vehicle, allowing of a certain degree of absorption of shocks in the case of their undergoing an upward or downward thrust as the sprung wheels are rolling along. The suspension is intended to make the pressure on the road-bed steady but the vertical tensile stress and the pressure on the suspension cause a rocking of the chassis, the period of the oscillations being on the one hand in relation to the mass of the chassis and the other hand to the pliability of the support. As the vertical rocking caused by the unevenness of the road of the track is repeated for a longer or shorter length of time after a shock has been undergone by the wheel, there may again occur, should there be a repetition of shock, a resonance between these vibrations and the swaying of the chassis and this increases the vertical swaying and the discomfort experienced by the load conveyed.

In order to remedy these inconveniences as far as possible, the wheel supporting axle is usually connected with the chassis by means of a shock-absorber the use of which is to operate against the movement of the spring. Whether its braking action is gradual or is applied one way only, however, it will be detrimental to the sensitiveness of the elastic support, even though it may previously have been devised as adjustable, or to a certain degree automatic according to the speed of the vehicle, the load conveyed, or the general condition of the road or railway-line, for the need of preserving the sensitiveness of the suspension retards the absorption of the rocking of the chassis resulting from shocks, this taking place even automatically as the result of adjusting the absorber or changing the resilience of the elastic support in relation with the working of the latter.

The device according to this invention can be achieved without lessening the sensitiveness of the suspension as regards the immediate deadening of the oscillation caused by an upward or downward thrust on the wheel as it moves along, the level of the chassis or weight conveyed remaining very much the same, that is to say, steady compared with the average level of the road-bed, this taking place obviously in so far as it is allowed by the compression and extension of the elastic support.

According to the present invention there is provided a suspension system for fitment between two relatively movable parts (such as the wheel of a vehicle and the transported load or chassis) which comprises two elastic members arranged or mounted so that the movement of the two relatively movable parts is equal to the sum of the two motions performed by the elastic members, said motions assuming different proportions in relation with each other, each one of said elastic members being controlled by an associated shock-absorber, said shock-absorbers having a one-way braking action, the effective braking of one shock-absorber being carried out in reverse direction to the other, one of said shock-absorbers being effective when the imposed load moves towards the other movable part, the second shock-absorber coming into action while said part is moving in opposite direction.

The suspension of this invention may be constructed in many different ways, the elastic support always including two springs, one working under compressive strain and the other under tensile stress in relation to an average position of equilibrium, each one of said members being appropriately controlled through the braking action of a shock-absorber.

In order to form a clear understanding of the characteristics of the invention and what its objects are, two different variants of its applications are herewith described and illustrated diagrammatically by way of example.

Thus are given the following diagrams in vertical section:—

Figure 1 illustrates an embodiment comprising suspension device supported by a rocking lever;

Figure 2 is an embodiment of the system represented in Figure 1;

Figure 3 is an axial section of an embodiment comprising a telescopic system with paired concentric coil-springs;

Figure 4 is one embodiment of a design of the shock-absorbing cylinder, in Figure 3, as seen in cross-section;

Figure 4A is a plan view of a form with a ball-and-socket joint for the mobile upper cam shown in Figure 3 with the arm connecting it to the fixed cam;

Figure 5 is a cross-section of Figure 3, passing through a piston;

Figure 6 is a device fitted with two springs and shock-absorbers placed end to end functioning by means of valves and by-passes;

Figure 7 is a device similar to the one on Figure 6;

Figure 8 is an embodiment similar to the one shown in Figure 6 in the form of a rotary movement;

Figure 9 is a section of Figure 6 passing through a piston;

Figure 10 is an embodiment similar to the one shown in Figure 1 fitted with an improvement;

Figure 11 is a part of Figure 6 fitted with an improvement similar to that on Figure 10;

Figure 12 is a form of the quick-cancelling system of the shock-absorber by the use of a slide-valve, as seen in cross-section and utilized in vertical section on Figure 10.

The different diagrams show by means of the same letters the elements which have similar functions on the successive figures.

Referring firstly to Figure 1 of the drawings the mass of chassis M bears on two vertical springs A^1 and B^1 whose lower ends rest on the ends m^1, n^1, of an arm pivoted to a horizontal axle O^1 forming one piece with a cheek F suspended on the hub R of a wheel held, as is usually done, by a draw-bar T hinged upon the chassis by means of a horizontal pin so as to allow a fairly vertical movement of the wheel and its hub, this being in proportion to the length of the bar T.

The arms of the lever m^1, n^1, that is n^1o^1 and o^1m^1 may be unequal only in this case the strength of the springs would then be made unequal.

Similarly, for the draw-bar T can be substituted, according to the circumstances, by a vertical slipper-guide forming one piece with the chassis.

The lever m^1n^1 can swing in a vertical plane releasing for example spring A^1 and compressing spring B^1.

The two arms of lever m^1n^1 are connected near their ends with two shock-absorbers H^1, K^1, which are connected at their other ends with the chassis M and act as brakes upon the working of each spring. The connection on the lever as well as the kind of shock-absorber used do not affect the principle of the invention.

Each shock-absorber has a one way action and one should act contrarywise to the other.

In order to obtain the maximum efficiency from the device, the connections and hinging upon the lever of each shock-absorber and its adjacent spring are devised to be close to each other if possible.

In this example the two shock-absorbers H^1 and K^1 are hydraulic shock-absorbers and provided with pistons so that shock-absorber H^1 allows the release of spring A^1 without any braking action but acts as a brake upon any compressing movement; whereas shock-absorber K^1 brakes the release and yet offers no resistance to the compression of its spring B^1.

Thus in Figure 1, spring A^1 (as well as all springs shown with reference letter A in all figures) can be compressed no more from the position shown. Said spring A^1 can be released and its release is not impeded by the shock-absorbing member H^1. The braking will be gradually effected by H^1 as spring A^1 being compressed resumes its position of equilibrium.

Conversely B^1, (as well as all springs shown with reference letter B in all figures), can only be compressed, the braking and immobilisation of it being effected as spring B^1 returns to the position shown without it being possible for said member to go beyond such a position.

The two shock-absorbers H^1 and K^1 are the usual type of damper. As above mentioned the braking effected on their respective springs is a one-way action only, said action being gradual or sudden. It is preferable however that the braking action should be gradual in the way in which it can be effected so that it becomes complete when the length of the flexing members become equal to the one assumed when the vehicle is at a standstill. Thus, in the position shown in Figure 1 spring A^1 can be compressed no more nor can spring B^1 be released any more.

Two stops S and Q limit the distance between bump and rebound. These stops are made of two strong springs or blocks of hard rubber, or any appropriate resilient checks.

The device works automatically as follows:

When the vehicle is at a standstill the lever m^1n^1 is stabilized on a given position called " starting position ", this position of the lever being effected in spite of any variations in the weight carried by the vehicle, since the highest efficiency of braking, as above defined, is never absolute but allows lever m^1n^1 to become stabilized when not in movement, as it is figured on diagram 1. In other words it is this starting position always assumed by lever m^1n^1 when the vehicle is at a standstill that is shown on this drawing. In theory, the immobilization of the springs at the initial or

starting position is considered as being absolute. In practice, the shock-absorbing fluid is slightly let through the pistons—by reducing their tightness—so as to allow said positions to go slowly beyond the initial position, which fact is of little consequence regarding the efficiency and enables the springs to adapt themselves to the variation of the imposed load. Thus, if the load conveyed is increased, the two springs are pressed down at unequal rates, but, after a few seconds and as the result of the initial adjustment, lever m^1n^1, gradually comes back to a starting position parallel with the first one, that is a horizontal one according to the example chosen. So it is quite possible as well to adopt for lever m^1n^1 a slanting starting position as, for example, by raising the point of connection with the chassis of spring A^1 and of its shock-absorber in relation with the point of connection of B^1, so as to obtain a starting position from which lever m^1n^1 would have a larger working space between the ground and the chassis, determined by the position of the stops S and Q, which can also be adjustable in their respective initial positions, such variants proceeding naturally from how the device is used and to what purpose.

On very uneven undulating ground, the variations in the level following each other rapidly, lever m^1n^1 assumes a very slanting position with relation to the starting position, at the same time as there occurs a steady fall of the chassis. The space allowed for the working up and down of the chassis is then appreciably reduced. The suspension is no longer aperiodic in its functioning and the stops come into action in order to limit the working space of the springs.

Limited to these working characteristics, the device according to the present invention is usable with sufficient efficiency in some practical applications. It would be then advisable to depart from the above theoretical data by reducing the braking action of each shock-absorber in such a way that in the starting position itself said action would not prove to be so strong. This would be done to keep a certain amount of sensitiveness in the suspension system together with sufficient scope in its working, in spite of very quick oscillations.

One can obtain a result equivalent to the one obtained as described above by placing the springs end to end (or co-axially) as shown in Figures 3, 6, 7 and 8, one said springs being connected with the chassis and the other with the ground wheel. Each spring is associated with its shock-absorber—the shock absorbers having a one-way action—i.e., one of them braking the upward and the other the downward movements. The functioning with the assembly shown in Figure 1—would be destroyed if the shock-absorbers were not set to operate contrarywise in relation with each other, or if one of the springs was not associated with a shock-absorber, or if one of the shock-absorbers controlled both springs at once by directly connecting the chassis (M) to the wheel (R). Such assemblies therefore do not come within the scope of the present invention.

In order to keep the full sensitiveness in the working up and down of the springs, an interconnecting device between the shock-absorbers, which is not shown in Figure 1, comes into play to restore the lever to its horizontal position by suitably relieving one of the springs, or the two together, from the action of its or their shock-absorbers This device is diagrammatized in Figure 3, its action can be thus defined: As soon as the spring A2, departs from the starting position, i.e., the position of equilibrium, it enables, its shock-absorber to act; the two following examples and two characteristic phases of operation—are to be considered;

(1) If the other spring B2 has itself remained in its starting position, a position assumed as previously explained when the vehicle is at a standstill, the shock-absorber H2 will act with the highest efficiency for which it is adjusted and also gradually, as befits a thorough braking action in order to enable the spring A2, to resume its initial position;

(2) If the other spring B2 has already departed from the starting position an appropriate cam (hereinafter referred to) comes into action all the more so in order to reduce the braking of the shock absorber as the other spring B2 has departed from said position. This spring A2 resumes its starting position much more quickly, and yet without going beyond it.

Thus, one of the springs acts as an automatic control of the shock-absorber of the other by making it less and less efficient in proportion as it itself departs from the starting position. Therefore it accelerates the return to this position.

If the interconnection device is applied to the assembly shown in Figure 1, in the case of both the springs departing symmetrically from the starting position—B2 working under compression and A2 under expansion—the two shock-absorbers greatly reduce their reciprocal braking action and the lever quickly returns to the horizontal or starting position. Although no lever is provided in Figure 3, the apparatus is similar in operation and achieves the results previously described. It represents 3 parts, each one moving in relation to the other, in a vertical telescopic sliding arrangement. The part joining the two tandem springs is arranged in such a way that the two springs may be concentric so as to reduce the length of the device.

The outside spring A2 cannot be compressed any further, nor can inside spring B2 expand beyond the position illustrated which is the starting position, these two springs bearing the

weight of the vehicle to which the device is hinged at point M, the wheel being connected at point R. Their operation is determined by two central shock-absorbers placed end to end in such a way that the upper shock-absorber H2 controls spring A2 and that shock-absorber K2 controls spring B2.

The shock-absorbers have a one-way action owing to valve-bearing pistons, these valves being fitted at angles ranging from 0° to 90° with relation to the axis of the cylinder and hinged on the periphery of the piston or working by flexion and closing upon a bevel-edge, they may vary in number and are made of appropriate material. Figure 3 shows two of these for each piston set at angles of 60° in relation to the cylinder axis. They can be made of a steel foil blade opening and closing by flexion.

A by-pass along a generatrix of the cylinders enables the fluid to flow from one cylinder end to the other as two respective cocks are opened. Each by-pass is controlled by a respective cock V, W fitted at one end of the cylinder, each one on the side and operated by rods resting with some flexibility on two respective cams X and Y. The cocks and their levers are carried by the median part formed by the cylinder and the cams are solid with the sliding tubular parts that carry the piston-rods. Figure 4 is a detailed view of the assembly.

The mobile cams X and Y act upon the cock-levers in two ways viz.: by relative axial movement between the cams and lever (slow progression) and by rotary motion of each cam on an axis that very nearly coincides with the point of contact of lever (D) of the cock (quick progression) when the corresponding spring is at the starting position

Cam X has its axis in J, and cam Y has its axis in L so that the motion of these cams round their respective axes will turn on the cock only if a sliding—as from position shown in Figure 3—caused by the contraction or expansion of the spring has been operated.

The mobile cams X and Y are operated by rods E and F, operating by alternating rotary motion, so that the two sliding parts which form them keep a constant connection with two fixed cams I and U. Two passages, vertical ones, as shown in the diagram, are devised for this purpose through the thickness of the wall of the shock-absorber cylinders. These rods, also, can be disposed outside both of the springs.

The fixed cam I is fitted to the lower piston rod and by its axial movement actuates the mobile cam X by means of a swingable lever actuated by rod E, running through the median part and clear of it, and hinged on the lower and upper parts. The two sections forming rod E make it extensible. Cam X follows the partial rotation of the shaft J on which it is mounted by means of the lever X^1 as shown but a system of gears could also be devised. The fixed cam U acts upon mobile cam Y in a similar way by means of its corresponding extensible and axially displaceable shaft F.

The way in which it operates is, according to the invention identical to the way in which the device on Figure 1 is operated, the two springs being associated with a resistive shock-absorber and the following description is only that of the shock-absorber which operates in connection with spring A2, devised to work under tensile stress.

Starting from the initial position the ground wheel being thrust downwards as the result of unevenness of road spring A2 expands whereas B2 remains immobilized by its shock-absorber. When the wheel goes upwards again, B2 will in its turn be compressed while A2 will be resisted and jammed by the shock-absorber, failing this return the equilibrium will be restored through a fall of the chassis, the shock absorber H2 being adjusted for the purpose. The cam X, not having revolved, acts then with maximum efficiency, but if the fall of the wheel occurs while spring B2 has been previously compressed, the cam X has revolved round its axis J as the result of the action of the shaft E acted upon by fixed cam I. It follows that the return to the starting position is much quicker for spring A2 than in the first instance in which B2 had remained in the starting position. Spring B2 operates in a similar way in regard to upward movements of the wheel. When the vehicle is at a standstill the two springs bear an equal share of the load conveyed, it being understood that an extra flexing member in parallel mounting can be provided to relieve the other flexing members, as shown in Figure 2.

Any suitable fluid can be used in the shock-absorber and the cocks and cams may be of the rotary or sliding type, the former devised as by-passes on the cylinder or the piston itself. Figure 4 represents a gradual flow-back of oil through a channel cut out in the cylinder wall, this channel as the result of the movement of the piston, having a varying width or even depth with a possibility of functioning in conjunction with a cock as in Figure 3 this cock being placed on the by-pass (*g*) (Figure 5).

Figure 5 is a horizontal section passing through a piston (S) of Figure 3. Figure 2 represents a variant of the device on Figure 1 regarding an alteration likewise applicable to the device on Figure 3 and made of a spring of low rate and connected in parallel to the device. This spring placed between the chassis and the wheel relieves the system by maintaining its characteristic of aperiodic functioning in as far as its stress is constant.

Should this added spring bear all the weight conveyed the two springs would be used solely to restore balance on an average position and would operate in two different directions, yet without modifying the working method of the

device proceeding from the invention. This case is illustrated by Figure 10.

It follows that the stabilization of the rocking achieved by the device presented can be applied to any mechanical system the purpose of which is to cancel the sustained swaying or parasitic resonance occurring in an attempt to achieve stabilization or regulation such as is seismographs, regulators of motor controls, for all kinds of engines, automatic steering.

Instead of the coil springs specified above flat springs, torsion rods, india-rubber springs, and air springs may be used. As in the device represented according to the variant of Figure 3; the cylinders and pistons could easily be reversed so as to make the piston integral with the median part while the cylinders would become mobile with the sliding parts on either side.

Similarly are included in the invention systems akin to the device presented but making use of springs with characteristics differing in flexibility and expansion or otherwise friction shock-absorbers instead of hydraulic ones. The same applies to variants making the flexibility of each spring more or less gradual in proportion as it has departed from the starting position, with, of course, a possibility for the springs to operate under tensile stress in order to bear the stabilised mass according to the classic system called: reversed springing. By "reversed springing" is understood an assembly in which the flexing members bear the imposed load so as to work under "tensile stress and not under compression".

Figures 6, 7 and 8 represent variants of application operating exactly like the device on Figure 3 but constructed with different means. The action of cams and cocks is dispensed with and for it are substituted by-passes for the shock-absorbing fluid which are controlled by the movement of the pistons acting as sliding valves on the walls of the cylinders. Figure 7, however, makes use of sliding telescopic tubes moving along the centre-line of the cylinder and whose different parts are integral with the pistons or with the cylinder-ends. Figure 9 is a horizontal section of Figure 6 passing through a piston.

In each Figure 3 parts are mobile in mutual relationship i.e., a practically oil-tight cylinder and two pistons. Each of these parts is hatched differently. The members playing the same part in the operation are hatched in the same way. It is to be noted that the part that connects the springs and that is not integral with either chassis or wheel—"floating part"—is cross-checked. The thickness left white represents openings allowing the flow of the fluid, a condition that can be achieved when the sliding allows the superposition of these openings and the disappearance of the solid walls.

One of these parts is integral with the chassis, another with the wheel, the third one is a median or floating part placed between the first two and connected to each of them by a spring.

In Figure 6, the two pistons are respectively integral with the chassis and the wheel, the cylinder is a floating member, therefore it has no valve but is provided with a sliding motion, so as to control the by-passes In Figure 7 the cylinder becomes integral with the wheel and carries the one-way valve.

Three compartments are thus created except in Figure 7 where an auxiliary compartment exists on the upper part, which is a typical arrangement called a magazine and destined to feed the shock-absorber with fluid by the action of a one-way valve. This arrangement can be applied to the other figures, the connection being established with the appropriate compartment owing to the depression which frequently occurs in it in relation with atmospheric pressure.

The stroke of each piston is limited, with relation to the median part, by dotted lines connected by arrows.

The fluid fills the three compartments. The pistons are fitted with valves as in Figure 3 making the pistons free from all braking action that might be caused by the fluid in one direction of the movement.

Each piston-rod or lever is controlled by a spring, which on the other end, rests upon the median part marked in cross-checked and which in Figure 6 is a rectilinear cylinder (l^1), in Figure 7 an intermediary piston l^2 without a rod,—here the cylinder is fitted with the one-way valve and in Figure 8, a cylinder l^3.

Figure 8 is the direct interpretation of Figure 6 by the action of pistons in rotary motion instead of the motion being rectilinear.

Figure 7 offers the advantage of a single sliding piston-rod requiring an oil-tight packing or stuffing-box avoiding leakage towards the outside. Its construction with rotary movement not offering any special advantage in this respect is not presented here, but such a construction could be no matter of innovation on the diagram with the rectilinear piston-stroke. The springs would indeed be inside the circular casing.

It is to be noted again in the three diagrams that the pistons delineate a compartment that is not partitioned and that the compartments placed on either side of the pistons are connected by a channel or by-pass b (b^1, b^2, b^3), the opening and closing of which is controlled at each end by the movement of each piston. In these assemblies the elimination of the partitioning between the two pistons (see Figure 3) is no obstacle to the independence of each braking action, the assembly being thereby simplified in the same way as when two circuits are superimposed in the case of an electrical device. The direction in which the valves operate is the same as regards the

fluid, which results, in fact, in a contrary action on the springs.

Finally, at the opposite end of the above mentioned by-pass each piston has a special by-pass a (a^1, a^2, a^3) whose action is permanent, and which works in such a way as to enable it to return slowly to the starting position, whenever the action of the spring caused it to depart from it.

The opening of by-pass b (b^1, b^2, b^3) at its two ends quickens for the two pistons together the return to their starting position. This acceleration ceases as soon as either of the pistons happens to be brought back to starting position, it then closes one end of by-pass b (b^1, b^2, b^3). The other piston then returns more slowly to its starting position under the sole action of its own by-pass a (a^1, a^2, a^3) in a way similar to that of a recoil-brake.

Thus there are two kinds of by-passes for fluid enabling the pistons to come back to their starting positions after departing from it without being braked. One (a) with a strong braking action which is permanent and peculiar to each of them, and a second one (b) with a fast fluid flow but intermittent and conditioned by reciprocal differences in the position of each piston as they are in motion.

The opening and the closing of these by-passes is not sudden and their progressiveness is secured by the variable depth of the openings in the walls of the cylinder as can be seen on the diagrams, or again by the variable width of the sliding parts, a design which cannot be represented in the diagram as seen in section, this width increases in proportion as the starting position is departed from, which is the position represented in the three figures.

Figures 6, 7 and 8 sum up many arrangements. Thus, in Figure 6 a spring A^4 is shown inside the shock-absorber and a spring B^4 on the outside. Four arrangements are thus possible. In the case represented, spring A^4 bears the chassis working under tensile stress (inversed suspension) and spring B^4 bears the chassis in a state of compression. This arrangement of flexing member A^4 is given as an example and only in Figure 6. Flexing member B^4 could still be inversed, or likewise both flexing members. Four arrangements are thus made possible in all assemblies. The operation would be the same but the words "compression" and "expansion" would naturally have to be interchanged in the explanations.

This same figure lends itself as well as Figure 3 to a system of outside concentric springs. An alteration of the piston would likewise allow the use of concentric springs in the arrangement on Figure 7, they being left inside the cylinder.

Let us consider, in the first place, in one of the Figures 6, 7 or 8, the action of the by-passes (a) peculiar to each piston and, provided the vehicle is at a standstill, let us raise the chsasis up to a retain height (h).

When it is released, the chassis will return to its level at the start without oscillating and without reaching a lower level than the one at the starting position, if the by-pass a is adjusted to that effect. Aperiodicity under these very limited conditions is absolute. But if, for this same adjustment, the chassis is raised up to a height $h+h$; the deadening will still be aperiodic, although the inertia of the chassis, as it comes down to level h, is modified by its impetus. This is commonly known as a result of the laws of hydraulics and the profile of the by-passes a. This is the very principle of recoil-brakes in which the outlets for the fluid have even a constant section and are devised in the piston.

In the second place, it remains to be provided that the acceleration produced by the ordinary by-pass does not influence the movements of the chassis in relation to ground level. Let us notice that this by-pass never causes any pushing aside of the springs from each other, it tends to reduce such action. This reduction is to be considered with relation to the median part, i.e., the level of O in diagram I.

In Figures 3, 6, 7 and 8, the space covered as the result of this reduction and in relation to the median part is in reversed direction and strictly the same. If the interconnecting device is applied in Figure 1 the angle of rotation of O^1 M^1 is the same as that of O^1 M^1 and the quantity of fluid lost by K^1 is the same as that recovered by H^1 because of this by-pass. The level of the median part is not therefore altered by this fact, but the compression of the springs is nevertheless modified.

Let us consider Figure 1, the vehicle being at a standstill. Let us tilt lever M^1 N^1 so as to release A^1 and compress B^1, and, at the same time, let us hold the chassis at its level in spite of there occurring a lifting power tending to raise it for the positive progressiveness of B^1 when compressed is greater than the negative progressiveness of A^1 when released. Let us simultaneously release the chassis and the lever. The lifting power ceases at the same time as the lever m^1 n^1 returns suddenly to a horizontal position. Under the above conditions the oscillations of the chassis are damped to a very large extent. Let us suppose that this lifting power has time to act and that for this purpose the chassis is first of all released. When in its turn m^1 n^1 is released, the chassis has risen up by h and if no account is taken of the time (a very short moment) when m^1 n^1 assumes a less slanting position with a complete release of B^1, spring A^1 is released by the same amount h. This amount will be reduced under the braking action of its shock-absorber by bringing the chassis back to its initial level i.e., by always stopping it at the half period.

This description as well as the following

concerns only a characteristic phase of the operation in which the role of the essential parts appears more clearly than if one considers any given stretch of road.

With the same mind, one can again consider the vehicle moving over an undulating ground causing regular and rapid upward and downward movements of the wheel. In practice, the braking of the shock-absorbers is then non-existent, for the symmetry of ups and downs constantly causes their reciprocal cancellation. But if one supposes that the chassis-spring system having its own period, starts for some reason an upward movement, there can be no other reason except an increase in the height of a portion of the road bed with the result that the average level of point O^1 (Figure 1) is raised. The symmetry between the position assumed by the spring when compressed and the one assumed by the spring when released is destroyed, the compression of spring A^1 working under tensile stress is not subject to any braking action, whereas the expansion of spring B^1 working under compression becomes subject to braking action near the starting position from which it had departed to a greater extent. This reduces the lifting power and brings the chassis back to its initial level.

The progressiveness in the action of the shock-absorber is shown as follows:—

Should the chassis be lowered when the vehicle is at a standstill and then afterwards released, it resumes its starting position without going beyond it. This resumption is impossible unless spring A^1 (Figure 1) is released at the moment when the braking action of shock-absorber K^1 slows down the speed at which spring B^1 is being released. The lessening of the braking action of B^1 produced by the release of A^1 must not therefore be too great and the opening of the by-passes or the action of cams must be gradual from the starting position.

In other words, before the release of B^1 is completed, a slight release of A^1 is inevitable owing to the braking action of B^1—the upward thrust of the chassis amounting to a decrease of the load when the acceleration becomes negative. This fact—a sort of bump—must not prevent immobilization of chassis at the position of equilibrium and not beyond it, if one is under the above stated conditions. Thus one has foundation for determining experimentally the optimum value of the profile of the by-passes or cams that control the braking action of the shock-absorbers.

The adjustment of the shock-absorbers themselves (by-pass a^1, a^2, a^3, in Figures 6, 7 and 8) may be practically defined as follows:—

Should the springs be relaxed (or compressed) without being held back by the inertia of the chassis but only by its weight, they would resume their length corresponding to the one at starting position according to a uniformly retarded movement.

Figure 10 diagrammatizes a device in which the stabilizing springs bear no weight, not being under any stress at the starting position. The adjustment as above defined would take no account of either inertia of chassis or of its weight.

Figure 10 represents a device which is an embodiment similar to that in Figure 1 i.e., a differential device in which a double rack-gear is substituted for the lever. On the other hand, the spring under steady strain designed in diagram 2 is here figured by spring C that entirely bears the weight of the chassis. The two springs (A6 and B6) operate only to bring back the chassis to the starting position.

The operation of the device on Figure 10 is the same as the one explained in the case of Figure 1 as regards the working of flexing members and shock-absorber. But the means used for accelerating the return of flexions to the length they assume when the vehicle is at a standstill by simultaneously reducing the action of each shock-absorber is different from the one used in Figures 3, 6, 7 and 8.

When the axle of the pinion of the rack-gear (O3) connected with the vehicle road wheel is at starting position, the two springs which come into gear with this pinion may likewise be compressed. A cam (Z_1) forming one piece with the wheel then acts upon a lever (Z_2) integral with the chassis to completely cancel the two shock-absorbers through a system of levers (Z_3 and Z_4) and this enables the two springs to be instantly released.

Theoretically, cam (Z^1) only acts at one point of their movement, i.e., whenever they reach the starting position in the process of their operation. In practice, cam Z_1 must possess a certain progressiveness according to the degree of sensitiveness desired. The interpretation of it in the form of a slide-valve in an oil shock-absorber is represented in Figure 12. This is the same system as the one represented in Figure 6, except in regard to the by-pass which is done away with, and for which there is substituted a communication taking place between compartments H4 and K4, when two extensions of the pistons, sliding along the cylinder wall and one against the other, have their respective apertures brought together, a position which is only achieved when the pistons are at equal distance from the starting point. The above communication occurs through the two extensions n^1 of the pistons which cancel the two braking actions of the dampers as does cam Z^2 in Figure 10 by acting upon the slide-valves shown in section view in Figure 11. In said view, it is to be noticed that the fluid freely flows from one part of the damper into the other but that a slight shifting of the slide valve would suffice to interrupt the flow, cam Z^2 being no longer

lifted. If the by-pass remains, the two systems can coexist on one and the same embodiment.

In addition to the principal device diagrammatized in Figure 1, the method of operation of Figure 3, 6, 7 and 8, is considered as being essential. The method of Figures 10 and 11 is shown as an improvement which can by itself suit special applications, but above all liable to be combined with the preceding one. According as slide valves and systems of cams and levers, are combined a great many devices becomes possible within the scope of the invention claimed.

What I claim is:—

1. A suspension system for fitment between two relatively movable parts (such as the wheel of a vehicle and the transported load or chassis) comprising two elastic members arranged or mounted so that the movement of the two relatively movable parts is equal to the sum of the two motions performed by the elastic members, said motions assuming different proportions in relation with each other, each one of said elastic members being controlled by an associated shock-absorber, said shock-absorbers having a one-way braking action, the effective braking of one shock-absorber being carried out in reverse direction to the other, one of said shock-absorbers being effective when the imposed load moves towards the other moveable part, the second shock-absorber coming into action whilst said part is moving in opposite direction.

2. A suspension system as claimed in Claim 1, wherein the braking of the shock absorbing members is gradual, and ranges from complete immobilization of each elastic member to no braking action whatever in the course of the movement of said elastic member.

3. A suspension system as claimed in Claim 2, wherein the maximum braking or immobilization takes place for each elastic member at the point of flexing reached when the imposed load is at a standstill, i.e. at the starting position, i.e., at the point of transition from bump to rebound, the elastic member jointly bearing its weight without swaying, such a position of equilibrium being called "initial or starting position".

4. A suspension system as claimed in Claim 2, wherein the braking action is not at its maximum at the initial or starting position, it being possible for each elastic member to go beyond said position owing to a gradually stronger braking action.

5. A suspension system as claimed in any of the preceding claims and embodying a mechanical or hydraulic interconnection allowing reduction of the braking operated by each shock-absorber upon its respective elastic member in so far as the opposite elastic member has already moved away from the initial or starting position, the maximum braking being nevertheless always attained at said position.

6. A suspension system as claimed in Claim 4, and utilizing the interconnection provided in Claim 6, but wherein the maximum braking action for each elastic member being then attained beyond the initial or starting position.

7. A suspension system as claimed in Claims 5 or 6, wherein the coupling between a shock absorber and elastic member is actuated mechanically.

8. A suspension system as claimed in Claim 7, wherein each elastic member is coupled by cam and rod assemblies to a shock absorber, to restrict braking action of the said absorber.

9. A suspension system as claimed in Claim 8, wherein a fixed cam, solid with one suspended part, and one mobile cam hinged on the other moveable part are provided between each elastic member and shock absorber.

10. A suspension system as claimed in Claim 9, wherein the elastic members comprise a pair of springs mounted in a telescopic assembly, which assembly also includes co-axially the shock absorbers of the fluid or hydraulic type, and means for operating cocks for controlling the fluid flow of the absorbers to regulate the braking action.

11. A suspension system as claimed in Claim 5, or 6, wherein the elastic members comprise springs which are arranged to control a passage or passages for the fluid of hydraulic shock absorbers, the movement of a piston of one absorber allowing, through said control, movement of the other.

12. A suspension system as claimed in Claim 11, wherein the pistons of two fluid shock absorbers are connected one to each relatively moveable part and are both located in a common cylinder, thus forming three sections therein i.e. between themselves and the two ends of the cylinder, each piston controlling the entrance of a by-pass passage connecting the two sections between the pistons and the ends of the cylinder.

13. A suspension system as claimed in Claim 12, wherein the pistons slide co-axially within the cylinder.

14. A suspension system as claimed in Claim 12, wherein the pistons operate by a rotary motion in the cylinder.

15. A suspension system as claimed in Claim 12, wherein the pistons of two fluid shock absorbers are mounted in a common cylinder to slide co-axially therein, with the one relatively moveable part connected to one piston at the one or upper end, and the other said part to the cylinder, with the other piston floating in the cylinder, there being compartments in the cylinder, the said pistons being coupled by means which control fluid flow between two of said compartments and having valve controls.

16. A suspension device as claimed in Claim 15, wherein the pistons are mutually coupled by co-axial tubes formed with co-

operating parts constituting portways with a valve controlled by-pass passage between the cylinder sections between the pistons and cylinder ends, a valve controlling flow of fluid from between the pistons to an end section, i.e. the upper end section, a spring in the intermediate cylinder section between the pistons, a spring in the lower end cylinder section, and a valve controlling fluid between said end cylinder sections.

17. A suspension system as claimed in Claims 3 to 16, wherein the braking action due to the shock absorbers is suddenly cancelled at a predetermined position of the springs from the starting position.

18. A suspension system as claimed in Claim 17, wherein the cancelling action is effected mechanically through a cam and lever construction.

19. A suspension system as claimed in Claim 17, wherein the cancelling action is effected hydraulically by the movement of the pistons and portways as passages.

20. A suspension system as claimed in Claim 19, wherein the pistons each carry a part having a passage therein, which passages, one of each part, align in the correct position for cancellation, and allow fluid to flow appropriately.

21. A suspension system as claimed in any of the preceding claims, wherein the weight of the one relatively moveable part or load is counterbalanced by an additional elastic member under substantially steady stress, whereby the two elastic members act only to stabilise the movements of the parts.

22. A suspension system substantially as herein described and with reference to any of the figures of the accompanying drawings.

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Published at the Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

FIG. 1.

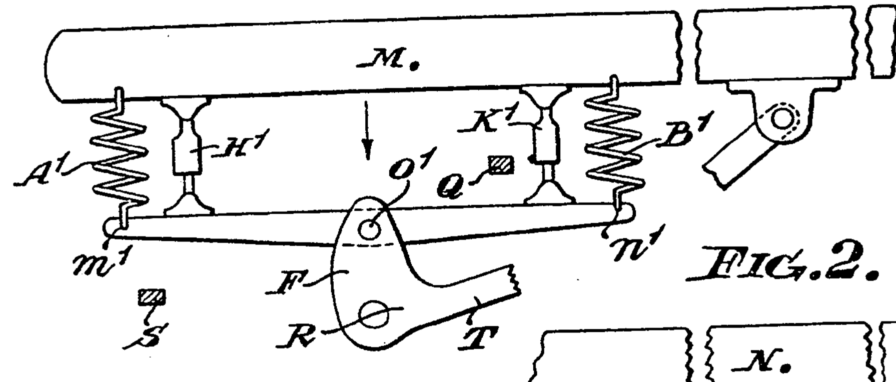


FIG. 2.

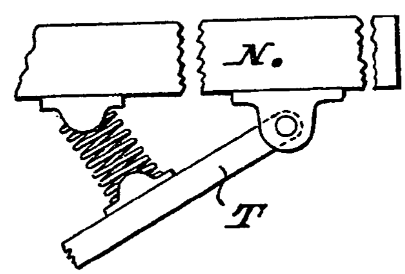


FIG. 3.

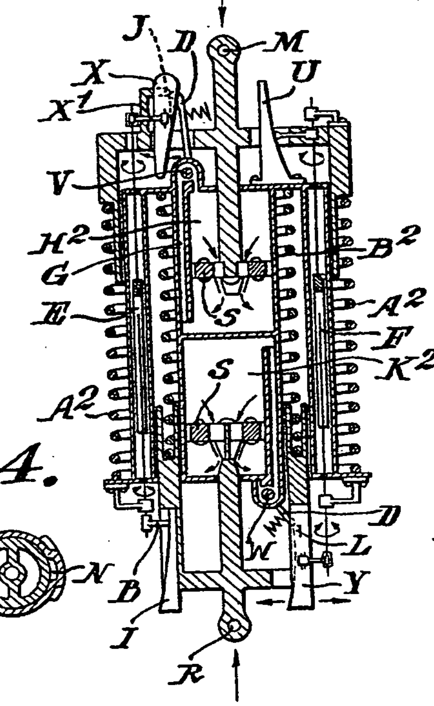


FIG. 4A.

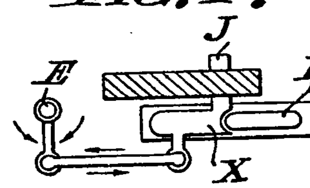
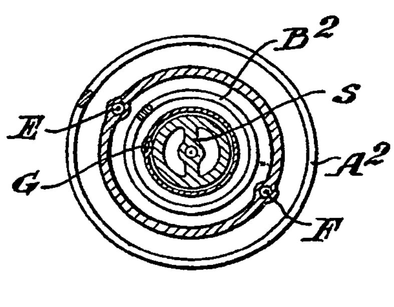


FIG. 5.



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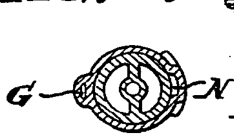


FIG. 7.

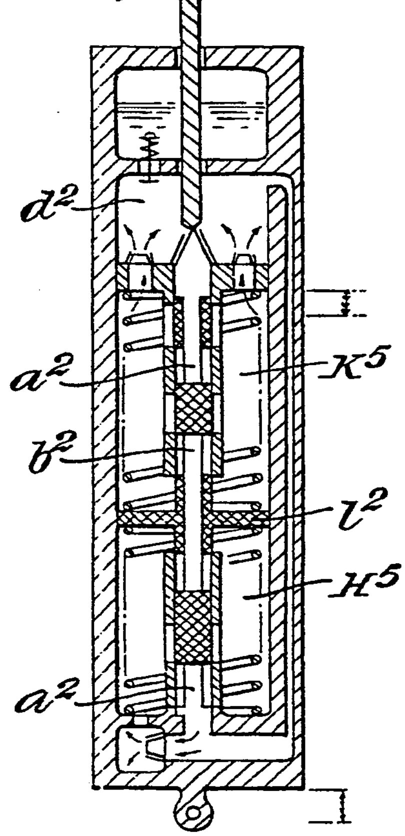


FIG. 6.

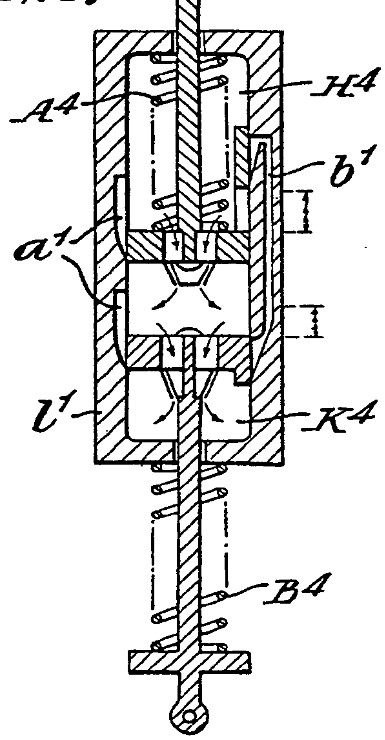


FIG. 9.

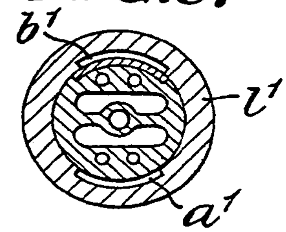
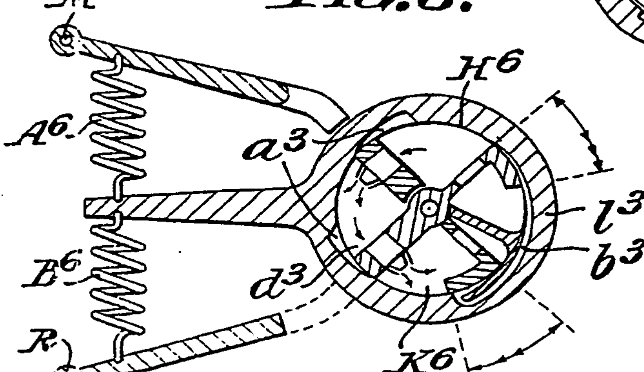


FIG. 8.



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3 SHEETS
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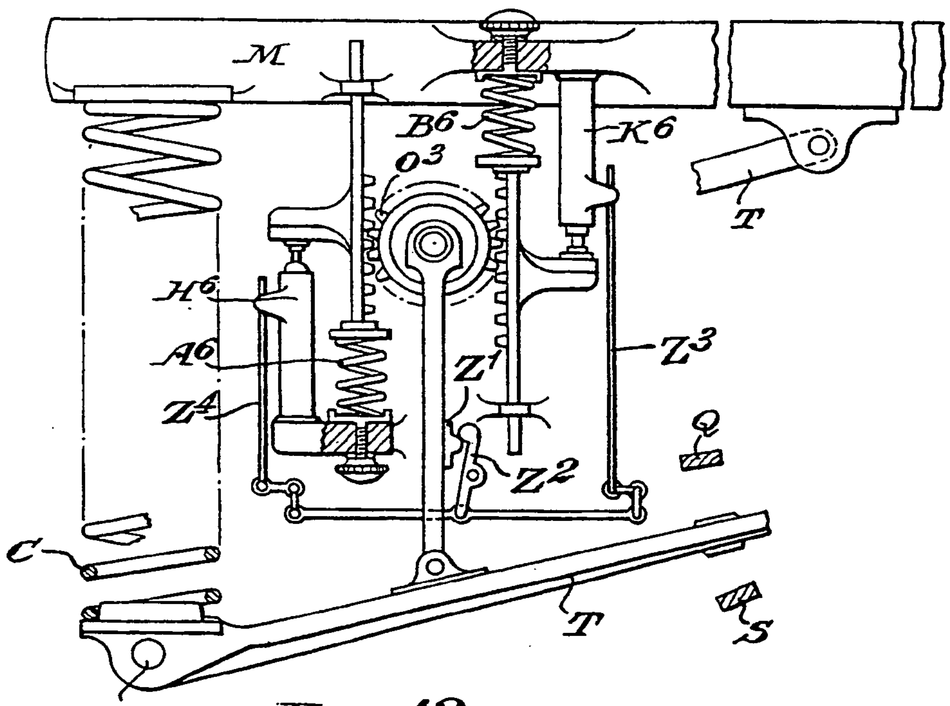
SHEETS 2 & 3

FIG. 10.



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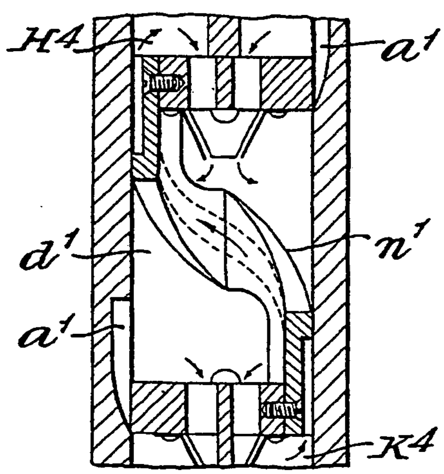
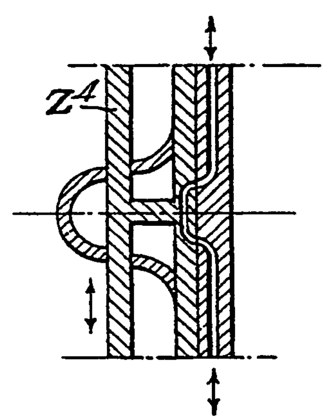


FIG. 11.



764,594 COMPLETE SPECIFICATION
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SHEETS 2 & 3

FIG. 7.

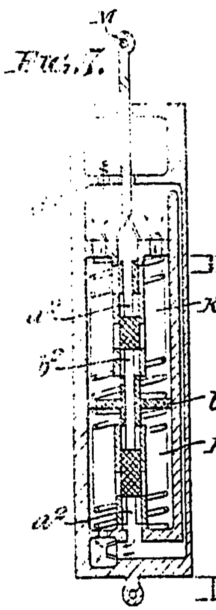

FIG. 6.

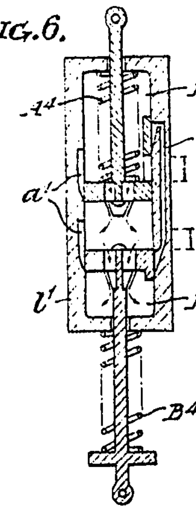

FIG. 10.

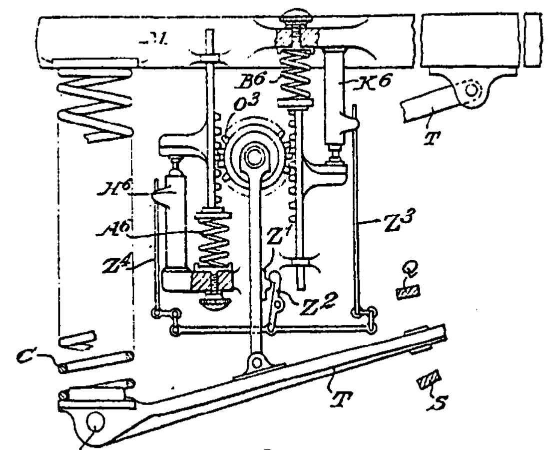

FIG. 9.

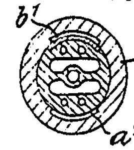

FIG. 8.

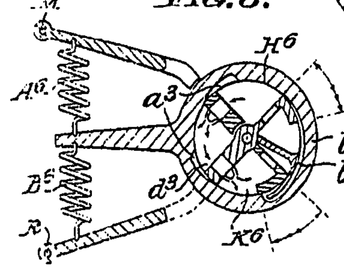

FIG. 12.

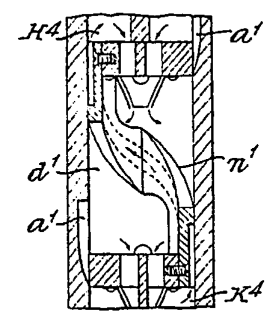

FIG. 11.